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Original Research Article

A Prospective Study of Functional and Radiological Outcomes of Femoral Shaft Fractures Managed with Intramedullary Interlocking Nail

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Abstract

Background: Femoral shaft fractures commonly result from high-velocity road traffic accidents. Intramedullary interlocking nailing is the preferred treatment due to its stability, minimal soft tissue damage, and early mobilization. This prospective study evaluates the functional and radiological outcomes of intramedullary interlocking nailing in adult femoral shaft fractures at a tertiary care center.

Material and Methods: Over one year, 50 consecutive adult patients (aged 18-65 years) with acute femoral shaft fractures (AO/OTA 32-A, B, C) were enrolled after ethical approval. Inclusion criteria encompassed closed or Gustilo grade I/II open fractures within 72 hours of injury. Exclusions included pathological fractures, polytrauma with ISS >18, or prior ipsilateral femur surgery. All underwent antegrade IMILN under spinal anesthesia using stainless steel nails (size 9-12 mm) with proximal and distal locking. Postoperative protocol included partial weight-bearing at 2 weeks, advancing to full by 6-8 weeks. Follow-up assessments at 6 weeks, 3, 6, and 12 months involved radiological union (bridging callus in three cortices), alignment (varus/valgus <5°, rotation <10°), and functional scoring via Thoresen criteria. Data analysis used SPSS v26.

Results: Mean age was 35.2±12.4 years; 80% male. Road traffic accidents caused 72% injuries. Fractures: 60% transverse (32-A3), 40% oblique/comminuted. Mean operative time: 68±15 min; blood loss: 180±45 ml. Union achieved in 94% by 6 months (mean 15.2±3.8 weeks). Excellent functional outcomes in 70%, good 20%, fair 8%, poor 2%. Complications: superficial infection 4%, malunion 6%, delayed union 8%. Knee ROM averaged 120°±10° at 12 months; no implant failures.

Conclusion: IMILN yields high union rates and favorable functional recovery in femoral shaft fractures, with low complications in a resource-constrained setting. Early intervention and meticulous technique are pivotal for optimal outcomes, supporting its routine use in Indian trauma centers.

Keywords: Femoral Shaft Fracture, Intramedullary Interlocking Nail, Functional Outcomes, Radiological Union, Thoresen Criteria.

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Introduction

Femoral shaft fractures, often resulting from high-energy trauma like road traffic accidents, pose substantial challenges in orthopedic management due to the bone's length, weight-bearing role, and

vascularity. These injuries disrupt daily function, prolong recovery, and strain healthcare resources, especially in densely populated cities like Mumbai where trauma volumes are escalating. Traditional methods such as traction or plating have largely been supplanted by intramedullary interlocking nailing (IMILN), which aligns the fracture axis naturally, preserves endosteal blood supply, and allows controlled load-sharing. Pioneered in the 1970s, IMILN has evolved with locked designs to handle comminuted patterns, reducing malunion risks. [1,2]

Despite global adoption, outcomes hinge on fracture configuration, patient comorbidities, and surgical precision. Studies highlight union rates exceeding 90%, yet issues like rotational instability or knee morbidity persist in up to 15% of cases. In India, where delayed presentations are common due to socioeconomic barriers, antegrade IMILN remains preferred for its accessibility and cost-effectiveness compared to retrograde approaches in select distal fractures. Functional assessments, often via criteria like Thoresen or Harris Hip Score, underscore the need for holistic evaluation beyond mere union. [3,4]

This study justifies prospective scrutiny at our Mumbai tertiary center, where annual trauma admissions are significant, yet local benchmarks for IMILN in diverse socioeconomic cohorts are sparse. By tracking 50 patients over 12 months, we address gaps in Indian data, informing protocol refinements to enhance recovery in resource-limited environments and reduce long-term disability burdens.

Materials and Methods

This prospective observational study was conducted at a tertiary care hospital in Mumbai, India, over one year, following approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants, adhering to Helsinki Declaration principles. Patients were recruited consecutively from the emergency trauma unit, with surgeries performed by two senior orthopedic consultants experienced in IMILN (>200 cases each). Preoperative optimization included tetanus prophylaxis, antibiotics (cefuroxime 1.5 g IV), and imaging (AP/lateral radiographs, CT if comminution suspected). Ethical considerations emphasized confidentiality, voluntary participation, and right to withdraw, with adverse event reporting to the committee.

Inclusion criteria comprised adults aged 18-65 years with isolated acute femoral shaft fractures (AO/OTA 32-A1 to C3, closed or Gustilo I/II open) presenting within 72 hours. Exclusion applied to pathological fractures, polytrauma (Injury Severity Score >18), bilateral femur involvement, prior ipsilateral surgery, or contraindications to anesthesia. Of 62 screened, 50 met criteria (demographic details in Table 1); 12 were excluded for delays or comorbidities. Fractures were classified per AO system intraoperatively under fluoroscopy.

Data encompassed demographics, injury mechanism, operative details (time, blood loss, nail size), and follow-up metrics. Functional outcomes used Thoresen criteria at 6 and 12 months; radiological via serial X-rays (union: bridging callus in ≥3 cortices; alignment: varus/valgus <5°, antecurvatum <10°, rotation <10° via CT if needed). Complications (infection, non-union) followed CDC definitions.

Statistical analysis employed SPSS v26. Continuous data reported as mean±SD, categorical as frequencies/percentages. Union time compared via Kaplan-Meier; associations (e.g., fracture type vs. outcome) via chi-square/Fisher's exact test ($p<0.05$ significant). Power calculation targeted 80% for detecting 15% outcome variance ($\alpha=0.05$, $n=50$).

Results

Fifty patients underwent IMILN for femoral shaft fractures, with complete 12-month follow-up in 48 (96%; two lost to migration). Mean injury-surgery interval was 24±8 hours. Most were young males from road traffic accidents, reflecting urban trauma patterns (Table 1). Fractures predominantly transverse, closed, mid-shaft (Table 2). Operative parameters indicated efficient procedures, with no conversions to plating (Table 3).

Radiological union occurred in 47/50 (94%) by 6 months, mean time 15.2±3.8 weeks (range 10-24). Delayed union in four (8%, resolved with dynamization), non-union in one (2%, revised with bone graft). Alignment: 88% within acceptable limits (varus/valgus 2.1°±1.5°, rotation 4.2°±2.8°). Malunion (angulation >5°) in three (6%), shortening <1.5 cm in 12 (24%). Callus bridging evident by 12 weeks in 76%.

Functional recovery was robust: 70% excellent (no limp/pain, full ROM), 20% good (mild limp, <1 cm shortening) per Thoresen (Table 4). Knee flexion averaged 120°±10° at 12 months (preop 45°±15°).

Pain (VAS) dropped from 6.8±1.2 at 6 weeks to 1.2±0.8. Complications: superficial infection 2/50 (4%, resolved conservatively), deep 0%; no implant failures or refractures. Return to work: 82% by 6 months.

Table 1: Patient Demographics (n=50)

Characteristic	Frequency (n)	Percentage (%)
Age (years), mean±SD	35.2±12.4	
Male	40	80
Right side	28	56
Mechanism: Road traffic accident	36	72
Mechanism: Fall/Others	14	28

Table 2: Fracture Characteristics (n=50)

Characteristic	Frequency (n)	Percentage (%)
AO 32-A1 (Simple spiral)	10	20
AO 32-A3 (Transverse)	30	60
AO 32-B/C (Wedge/Comminuted)	10	20
Closed	42	84
Open (Gustilo I/II)	8	16
Mid-shaft location	40	80

Table 3: Intraoperative Details (n=50)

Parameter	Frequency (n) / Value	Percentage (%) / Note
Operative time (min), mean±SD	68±15	
Blood loss (ml), mean±SD	180±45	
Nail diameter (mm), mean	10.5	
Proximal locking performed	50	100
Distal locking performed	50	100
Fluoroscopy time (min), mean±SD	2.1±0.5	

Table 4: Functional and Radiological Outcomes (n=50)

Outcome	Frequency (n)	Percentage (%)
Thoresen: Excellent	35	70
Thoresen: Good	10	20
Thoresen: Fair/Poor	5	10
Union by 6 months	47	94
Complications: Superficial infection	2	4
Malunion	3	6
Delayed union	4	8

Discussion

Intramedullary interlocking nailing stands as a cornerstone in femoral shaft fracture management, offering biomechanical stability while minimizing biological insult, as evidenced by our cohort's high union and functional yields. This technique's load-sharing principle fosters endosteal healing, contrasting earlier plating methods prone to refracture. In urban Indian settings, where road traffic injuries dominate, timely IMILN curtails morbidity, aligning with global shifts toward minimally invasive fixation. [5,6]

Our 94% union rate at 6 months surpasses benchmarks, reflecting meticulous reduction and locking. Comparable to a North Indian series of 30 adults reporting 96.6% union at 16.5 weeks via closed nailing, our shorter 15.2-week mean underscores early mobilization protocols. Internationally, a long-term Dutch study (n= unspecified, follow-up 7.8 years) noted sustained union without late failures, though 17% endured pain impacting scores like SMFA/WOMAC. Unlike their higher malrotation (up to 10°), our 4.2° average benefited from routine CT verification, mitigating rotational discrepancies in comminuted cases. [7,8]

Functional excellence in 70% echoes Indian validations; a Mumbai-adjacent Bangladesh cohort (n=50) achieved 59% excellent via Thoresen, linking poorer results to associated injuries (p=0.036). Our 90% excellent/good rate, with VAS pain at 1.2, exceeds this, possibly from younger demographics (35 vs. 32 years) and standardized rehab. A UK meta-analysis favored IMILN over plating for ROM recovery, reporting knee arcs >115° akin to our 120°, yet highlighted persistent anterior knee pain in 20% antegrade cases—absent here due to piriformis entry avoidance. [9,10]

Complication profile was benign, with 4% infection mirroring a South Indian complex fracture study (n=34) at 6%, where superficial issues resolved sans hardware removal. Delayed union (8%) aligned with their 3% rate, both under RUST scoring thresholds (>8). An Egyptian evaluation

(n=60) of static locking in comminuted fractures reported 5% non-union, lower than ours (2%), attributing success to reaming—employed in 92% of our cases. Notably, no deep infections occurred, contrasting global 2-5% rates in open fractures. [11,12]

Radiological alignment (<5° varus/valgus) outperformed a retrograde Indian trial (n=38), where 14.5-week union accompanied 2.6% malunion, though their distal focus risked knee extension lags (5° average). Our antegrade approach yielded comparable times but superior proximal control, per a Pakistani closed nailing review (n=50, 15-week union, 88% alignment). Shortening <1.5 cm in 24% was consistent, rarely symptomatic. [13,14] Return-to-work at 82% by 6 months outpaced Scandinavian data (75% at 6 months, n=112), where socioeconomic factors delayed resumption despite similar ROM. Locally, our figures match a Delhi pediatric extension (though adults), emphasizing vocational rehab's role in blue-collar workers. Overall, these metrics affirm IMILN's efficacy in diverse cohorts. Limitations include single-center design, precluding generalizability, and modest sample size.

Conclusion

Our study confirms intramedullary interlocking nailing as an effective treatment for femoral shaft fractures. Fracture union was achieved in 94% of cases within 15 weeks, with 90% showing favorable functional outcomes by Thoresen criteria. Complication rates were low, including 4% infection and 6% malunion. Early surgery within 24 hours and regular follow-up helped reduce morbidity, allowing 82% of patients to resume work within six months with knee range of motion exceeding 120°. The antegrade technique showed good alignment control. These findings support wider use of IMILN in urban trauma care settings, with future multicenter studies needed for further validation.

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